Claims

1. A method to obtain contamination free surfaces of a material chosen from the group comprising GaAs, GaAlAs, InGaAs, InGaAsP and InGaAs at crystal mirror facets for GaAs based laser cavities, comprising:

Sub B2

- cleaving out said crystal mirrors facets exposed to an ambient atmosphere containing a material from the group comprising air, dry air, or dry nitrogen ambients;
- removing any oxides and other foreign contaminants obtained during the ambient atmosphere exposure of the mirror facets by dry etching in vacuum;
- growing, after having the oxides removed, a native nitride layer on the mirror facets by treating them with nitrogen.

2. A method according to claim 1, further comprising:

- starting said dry etching using a substance assisted plasma comprising at least one substance from the group comprising chemically inert and reactive gases, such as nitrogen, hydrogen, argon and halogen compounds (e.g. Cl, Br, or I based compounds) and hydrocarbon gases (e.g. CH_4 and C_2H_6), and mixtures of them;
- passivating the facets after obtaining a contamination free surface by using a nitrogen assisted plasma.

3. The method according to claim 2, wherein said dry etching is performed with a nitrogen assisted plasma.

4. The method according to claim 2, wherein said dry etching is performed with a plasma wherein the substance is a mixture of nitrogen and another gas, said other gas being gradually replaced by nitrogen until only nitrogen plasma is provided.

5. The method according to claim 2, wherein said dry etching is performed with a gas free of nitrogen, said gas being gradually replaced by nitrogen until only nitrogen plasma is provided.

Sub A'

6. The method according to any of claims 2-5, wherein said nitrogen plasma contains nitrogen ions in the atomic or molecular form, or a mixture of these.

7. The method according to any of claims 2-5, wherein said nitrogen plasma contains neutral atomic nitrogen.

Sub A1

8. The method according to any of claims 2-5, wherein said nitrogen plasma contains molecular nitrogen.

9. The method according to claim 2, further comprising: adding hydrogen to said substance assisted plasma for enhancing removal of oxides.

10. The method according to claim 2, wherein said substance is argon.

Sub B3

11. The method according to claim 1, wherein said GaAlAs-InGaAs surfaces at crystal mirror facets also comprise an element from the group comprising Sb and Se.

12. The method according to claim 2, further comprising:

- starting to grow a nitride layer onto said contamination free surface during introduction of an element from the group comprising ionic nitrogen, atomic nitrogen and molecular nitrogen to said substance assisted plasma and in reaction with GaAlAs-InGaAs layers provided during said cleaving of said laser facets;
- making an interface between each cleaned facet and said grown nitride layer gradual making use of a native nitridisation in order to minimize interface recombination between different layers.

13. A method according to claim 12, further comprising: creating said nitride layer using plasma comprising nitrogen with an extracted beam, said nitide layer consisting of at least one material from the group comprising AlN, GaN, InN, InAsN.

14. A method according to claim 1, further comprising: additional insitu or exsitu deposition of a thin nitride film using reactive plasma in combination with nitrogen and at least one element from the periodic table groups 2b, 3a, 4a and 5a, such as C, Si, Ga, Zn and Al.

15. A method according to claim 14, further comprising: adding at least one further film to further reduce interface surface recombination prior to mirror coating.

16. A method according to claim 1, further comprising:

enhancing smooth surface morphology at said dry etching with specific energy range 0 to 2000 eV in combination with alternate incident beam angles from 0° to 90° from a normal incident angle.

17. A method to obtain crystal mirror facets for a laser cavity in a laser body, comprising;
(i) cleaving out said crystal mirrors facets exposed to an ambient atmosphere containing one of the following materials: air, dry air, or dry nitrogen ambients;
(ii) making ion-milling in vacuum to remove a contamination layer provided at said cleaving; and
(iii) forming near-surface nitrided compounds by an ion-milling incorporating nitrogen, said nitrided compounds normally have band-gaps higher than their counter parts and prevent subsequent undesirable chemical contamination.

18. A method according to claim 17, further comprising:
before forming said near-surface nitride compounds:
obtaining a contamination free surface by dry etching using an argon gas assisted plasma;
passivating the facets after obtaining a contamination free surface by adding nitrogen gas to said argon gas assisted plasma to provide a native nitridisation of said contamination free surface.

19. A method according to claim 18, wherein said passivating the facet is provided by gradually removing argon until only nitrogen plasma is provided.

20. A method according to claim 19, further comprising:
starting to grow a nitride layer onto said contamination free surface during introduction of said nitrogen to said argon gas assisted plasma and in reaction with laser bar layers provided during said cleaving of said laser facets;
making an interface between each cleaned facet and said grown nitride layer gradual making use of said native nitridisation in order to minimize interface recombination between different layers.

21. A method according to claim 18, further comprising:
adding hydrogen to the argon gas assisted plasma for enhancing removal of oxides.

22. A method according to claim 17, further comprising:
enhancing smooth surface morphology at said dry etching with specific energy range 0 to 2000 eV in combination with alternate incident beam angles from 0° to 90° from a normal incident angle.

Sub B1

23. A method according to claim 20, further comprising:
creating said nitride layer using plasma comprising nitrogen with an extracted beam. said nitride layer consisting of at least one material from the group comprising AlN, GaN, InN, InAsN.

24. A method according to claim 22, further comprising: additional insitu or exsitu deposition of a thin nitride film using reactive plasma in combination with at least one element from the periodic table groups 2b, 3a, 4a and 5a, such as Si, Ga, Zn, and Al.

25. A method according to claim 24, further comprising: adding at least one further film to further reduce interface surface recombination prior to mirror coating.

26. A method to obtain laser diodes from a laser wafer, comprising:

- cleaving the laser wafer into bars in ambient atmosphere providing a first and a second facet;
- stacking said cleaved bars in a 2D-matrix;
- placing the matrix in vacuum between 10 Torr to 10^{-11} Torr, preferably less than 10^{-7} Torr;
- removing surface oxide and contamination from said first and second facets using dry etching, for instance ion-beam etching, using a plasma comprising at least one material from the group comprising chemically inert and reactive gases, such as nitrogen, hydrogen, argon, halogen (e.g. Cl, Br, or I based compounds) and hydrocarbon gases (e.g. CH_4 and C_2H_6), and mixtures thereof;
- creation of a first nitrided surface layer on said first and second facets using plasma containing nitrogen, the nitrogen ions being accelerated from the plasma to the surface (e.g. extracted as an ion beam), the nitrided layer consisting of at least one of compound from the group comprising AlN, GaN, InN, InAsN;
- forming a second nitrided layer comprising at least one element from from the periodic table groups 2b, 3a, 4a and 5a, such as Al, In, Ga, As, and P.
- forming at least one third additional insitu or exsitu deposition of thin nitride film layer using reactive plasma in combination with at least one element from the periodic table groups 2b, 3a, 4a and 5a , such as Si, Ga, Zn, and Al;
- adding at least one thin passivation layer film to further reduce interface/surface recombination prior to mirror coating; and
- adding a protective layer and/or a mirror coating.

27. The method according to claim 26, further comprising: enhansing smooth surface morphology at dry etching (plasma sputtering or ion beam etching) with specific energy range 0 to 2000 eV in combination with alternate incident beam angles from 0° to 90° from the normal incident angle.

28. The method according to claim 26, further comprising:

producing the deposited and nitridised layers in combination followed by an annealing procedure.

29. The method according to claim 26, wherein said dry etching and first nitridation step comprises forming the gas into plasma by supplying microwave electric power to the gas.

30. The method according to claim 26, wherein:
said dry etching and first nitridation step comprises forming the gas into a plasma by supplying radio frequency electric power to the gas.

31 The method according to claim 26, wherein:
said dry etching and first nitridation step comprises forming the gas into a plasma by supplying DC electric power to the gas.

Sub B5

32. The method according to claim 26, wherein:
said mixture between said reactive gases and inert gases comprises at least one element from the group comprising argon, nitrogen, hydrogen and chlorine.

33. The method according to claim 26, wherein said creation of a first nitrided surface layer uses a nitrogen ion beam extracted from a plasma containing nitrogen gas, said plasma comprising at least one element from the group comprising hydrogen and argon.

34. The method according to claim 26, wherein said second nitrided layer consists of predominantly nitrogen bonded to group III elements.

Sub B6

35. A method to passivate a laser mirror comprising layers of GaAlAs-InGaAs after obtaining a first and a second contamination free laser mirror facet surface, comprising:
adding nitrogen gas to an argon plasma and gradually removing argon until only nitrogen plasma is provided in a step like manner,
growing a nitride layer during introduction of the nitrogen onto and in reaction with said GaAlAs-InGaAs layers making the interface between said contamination free facet surface and said nitride layer gradual, said nitride layer gradually making use of a native nitridisation in order to obtain a gradual border line between said layers.

add B7